

Description of *Meloidogyne ichinohei* n. sp. (Nematoda:
Meloidogynidae) from *Iris laevigata* in Japan*

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A new root-knot nematode, *Meloidogyne ichinohei* n. sp., detected from *Iris laevigata* (rabbit-ear iris) cultivated in a paddy field in Hisayama, Fukuoka, Kyushu is described and illustrated. This new species has unique combination of characters and can be differentiated from all other known *Meloidogyne* spp. including morphologically similar species such as *M. acronea* and *M. megriensis* having posterior-protuberances in females. The female has prominent posterior-protuberance, laterally located neck, perineal pattern made up by extraordinarily faint and broken striae, stylet 12.3 μm long and excretory pore located about four times the stylet length behind the stylet knob. The second-stage juvenile has a hemizonid located just in front of the excretory pore, undilated rectum, body length of 470 μm , a-value of 31.3, tail length of 54.2 μm , stylet length of 11.3 μm and distance of 5.2 μm from the dorsal gland orifice to the base of stylet. The shape of the hyaline tail of the second-stage juvenile is usually triangular, but variant forms with protruded tail tips sometimes appear. The males are very rare. The only known host plant of this species is *I. laevigata*. Egg masses are produced within usually terminal galls. *Jpn. J. Nematol.* 22: 11-20 (1992).

Key words: Root-knot nematodes, morphology, new species, taxonomy.

A *Meloidogyne* population having extraordinary biological characters was found during an investigation on the taxonomy and species distribution of root-knot nematodes mainly of cultivated fields in Kyushu. It parasitizes *Iris laevigata* (rabbit ear iris), the only known host, inducing galls, often on the root termini (Fig. 1A) with eggs and egg masses usually deposited inside the galls (Fig. 1B). This *Meloidogyne* population has unique morphological characters, so is described as a new species, *Meloidogyne ichinohei* n. sp.. ARAI²⁾ and ICHINOHE⁸⁾ independently reported the occurrences of a root-knot nematode parasitizing *Iris laevigata* from Honshu in 1967, and the descriptions available coincide with that of *Meloidogyne ichinohei* n. sp.. It seems likely that this *Meloidogyne* sp. is identical to *Meloidogyne ichinohei* n. sp. and therefore, *M. ichinohei* n. sp. is present also in Honshu.

There are eight known *Meloidogyne* species from Japan so far. They include *M. incognita*^{9, 14)}, *M. javanica*^{9, 14)}, *M. hapla*^{9, 14)}, *M. arenaria*^{9, 14)}, *M. mali*^{9, 14)}, *M. camelliae*^{1, 9)}, *M. suginamiensis*¹⁶⁾ and *M. graminis*^{7, 12)}. The record of *M. thamesi* has been eliminated by TOIDA and YAEGASHI¹⁷⁾. There is also a recent report on *M. marylandi*³⁾. There are nine *Meloidogyne* species recorded from Japan.

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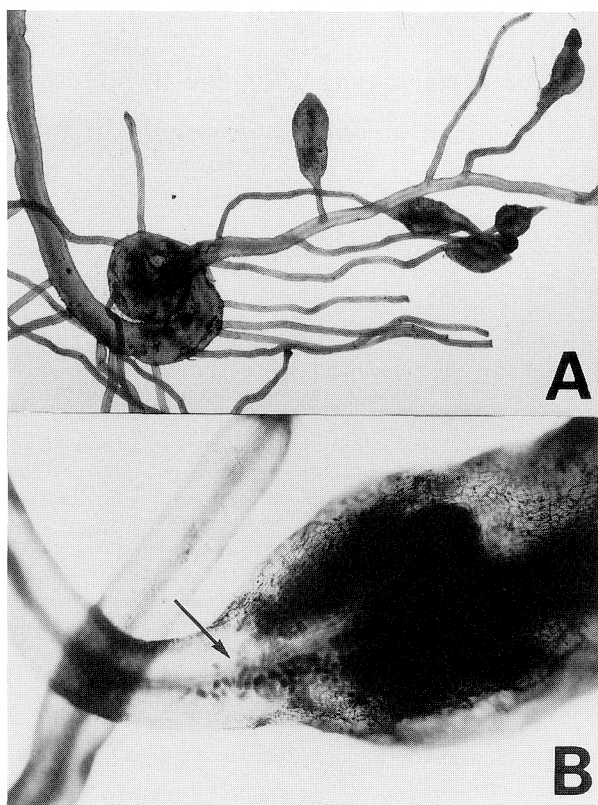


Fig. 1. Galls caused by *Meloidogyne ichinohei* n. sp. (A, B). Note that the galls are often terminal (A), and that no egg sac is observed outside the galls but eggs are visible within a gall (arrow, B).

MATERIALS AND METHODS

Iris laevigata infected with *M. ichinohei* n. sp. were collected in 1983 in Hisayama, Fukuoka, Kyushu and maintained in pot culture at the Kyushu National Agricultural Experiment Station. The adult females were fixed and measured in lactophenol. Perineal patterns were prepared and mounted in lactophenol¹⁵⁾. Second-stage juveniles freshly hatched from egg masses in distilled water were mounted and measured in 1% folmardehyde⁶⁾. Type series materials except males were killed in a hot water bath of 65 °C, fixed with TAF, and mounted in glycerin using the Seinhorst's glycerol-ethanol method¹⁵⁾. Allotype and a paratype males were killed and fixed in lactophenol and mounted in the same medium. Eggs were mounted in distilled water and measured. Females in galls were stained in hot lactophenol containing 0.005% aniline blue¹⁵⁾. Line drawings of the specimens were made using a drawing tube, and measurements were calculated with a curvimeter.

RESULTS AND DISCUSSION

1) Description

(1) Holotype (female in glycerin): Body length 857.5 μm (along the center line of the body,

length excluding neck 611.3 μm), neck length 246.3 μm , body width 396.3 μm , stylet length 13.1 μm , stylet knob height 1.8 μm , stylet knob width 3.1 μm , dorsal esophageal gland orifice to stylet base (DGO) 4.1 μm , excretory pore to anterior end 49.9 μm ; ratios-a 2.2, linear body length/body width 1.54, stylet knob width/height 1.7.

(2) Females: Measurements of 10 females in lactophenol and of the holotype and 8 paratype females in glycerin are presented in Table 1 and Table 2, respectively. Body globular to ellipsoidal, pearly white, variable in size; neck prominent, situated always on the ventral side of the body; posterior end of body with prominent and undulate posterior-protuberance (Fig. 2A). Body cuticle annulated. Head region set off, usually marked by an annule. Head cap distinct, cephalic framework weakly sclerotized; vestibule and vestibule extension distinct (Fig. 2B). Stylet relatively short and delicate; stylet cone dorsally curved; shaft cylindrical (Fig. 2B). Stylet knobs separated, set off from shaft, transversely ovoid. DGO 5.4 μm . Excretory pore located about four times stylet length behind stylet knobs (Fig. 2B).

Perineal patterns (Figs. 2C; 4A-B) are difficult to prepare due to the prominent posterior protuberance. The area around anus is usually covered by the fold of the tail tip. Shape of the perineal pattern rounded; striae extremely faint, broken and somewhat spaced. Vulva slit like,

Table 1. Measurements of *Meloidogyne ichinohei* n. sp. females in lactophenol.

Character	Range	Mean	SE	SD	CV(%)
Linear (μm)					
Stylet length	11.0-13.6	12.3	0.24	0.77	6.28
Stylet knob height	1.8-2.4	2.1	0.06	0.20	9.62
Stylet knob width	3.3-4.6	4.1	0.12	0.38	9.23
Stylet knob to head end	12.2-16.3	14.0	0.43	1.37	9.76
DGO	3.8-6.8	5.4	0.28	0.88	16.28
Excretory pore to head end (EPH)	36.7-62.0	48.7	2.62	8.28	17.02
Vulval slit length	25.5-46.1	34.2	1.96	6.20	18.14
Vulva-anus length	14.1-29.6	25.1	1.43	4.53	18.09
Ratios					
EPH/stylet base to head end	2.9-4.7	3.6	0.19	0.61	17.08

Measurements from 10 females.

Table 2. Measurements of *Meloidogyne ichinohei* n. sp. females in glycerin.

Character	Range	Mean	SE	SD	CV(%)
Linear (μm)					
Body length (along the center line)	618.8-1018.8	796.1	38.16	114.48	14.38
Body length without neck	396.3-690.0	529.6	29.85	89.54	16.91
Body width	300.0-575.0	393.2	31.09	93.27	23.72
Neck length	135.0-246.3	195.7	15.08	45.23	23.11
Neck width	51.3-135.0	86.4	10.65	31.95	36.98
Height of posterior protuberance	37.5-52.5	47.2	1.51	4.54	9.62
Ratios					
a	1.5-2.6	2.1	0.12	0.35	16.74
Body length without neck/Body width	1.3-2.0	1.5	0.07	0.21	13.51
Stylet knob width/height	1.5-2.4	2.0	0.08	0.26	13.54

Measurements of the holotype and 8 paratype females.

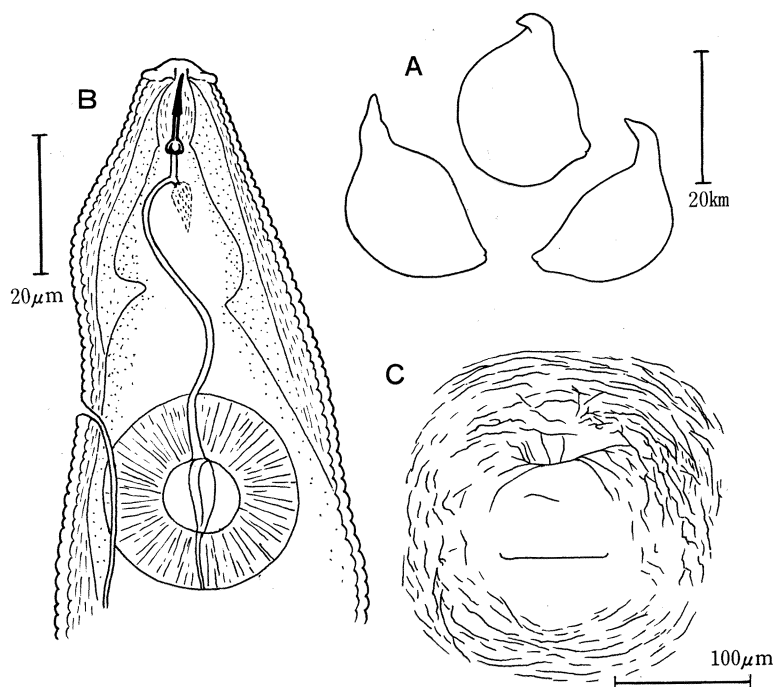


Fig. 2. Line drawings of females of *Meloidogyne ichinohei* n. sp. A) Body shapes of adult females. B) Esophageal region (lateral). C) Perineal pattern.

Table 3. Measurements of males of *Meloidogyne ichinohei* n. sp.

Character	Range	Mean
Linear (μm)		
Body length	1450.8-1581.0	1516.0
Greatest body width	41.0-44.4	42.7
Body width at stylet base	17.5-20.0	18.8
Body width at excretory pore	29.2-32.8	31.0
Body width at anus	16.8-20.1	18.4
Stylet length	16.64-17.41	17.0
Stylet knob height	3.1-3.2	3.4
Stylet knob width	3.8-4.2	4.0
DGO	6.1-6.9	6.2
Head end to metacarpus valve	71.4-79.5	75.5
Excretory pore to head end	140.8-131.0	135.9
Tail length	12.8-13.8	13.3
Spicule length	32.9-33.7	33.3
Gubernaculum length	8.4-9.3	8.9
Ratios		
a	32.7-38.3	35.5
Stylet knob width/height	1.3	1.3
c	113.3-114.5	113.9
Percentage		
Excretory pore	8.3-9.7	9.0

Measurements of the allotype and a paratype males in lactophenol.

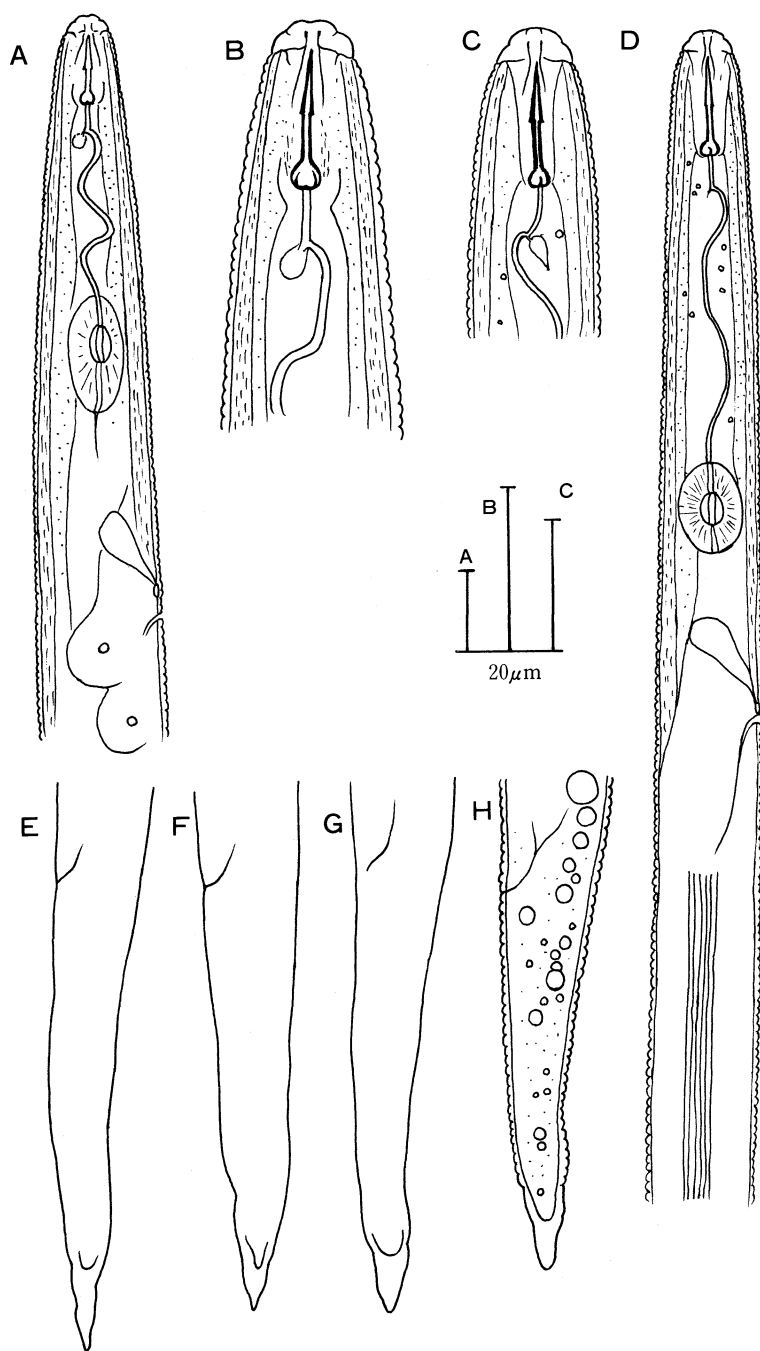


Fig. 3. Line drawings of males and second-stage juveniles of *Meloidogyne ichinohei* n. sp. A) Esophageal region of male (lateral). B) Cephalic region of male (lateral). C) Cephalic region of second-stage juvenile (lateral). D) Esophageal region of second-stage juvenile (lateral). E-H) Tails of second-stage juveniles (lateral).

Table 4. Measurements of second-stage juveniles of *Meloidogyne ichinohei* n. sp.

Character	Range	Mean	SE	SD	CV(%)
Linear (μm)					
Body length	413.1-524.3	469.6	2.10	19.97	4.25
Greatest body width	14.1-16.0	15.0	0.05	0.45	3.02
Body width at anus	9.0-11.4	10.2	0.06	0.59	5.80
Stylet length	9.7-12.9	11.3	0.07	0.68	6.05
Stylet base to head end	13.8-16.6	15.7	0.06	0.54	3.45
DGO	3.6-6.4	5.2	0.06	0.59	11.31
Head end to metacarpus valve	49.5-98.9	63.2	0.98	7.37	11.66
Tail length	37.5-69.6	54.2	0.63	5.98	11.04
Hyaline tail length	2.9-17.7	7.7	0.30	2.80	36.38
Ratios					
a	27.1-34.9	31.3	0.18	1.70	5.44
Body length/head end to metacarpus valve	7.4-9.3	9.2	0.68	0.09	5.20
c	7.0-12.1	8.8	0.09	0.82	9.32
tail length/width at anus (c')	3.7-6.8	5.3	0.07	0.68	12.78

Measurements from 90 second stage juveniles in 1% formaldehyde.

without surrounding striae; phasmids small, obscure. Interphasmidial distance $14.2 \mu\text{m}$. Dorsal arch low and rounded; lateral lines absent, sometimes with lines of particles instead. Ventral pattern region rounded.

(3) Allotype (male in lactophenol): Body length $1450.8 \mu\text{m}$, greatest body width $44.4 \mu\text{m}$, body width at stylet base $20.0 \mu\text{m}$, DGO $6.9 \mu\text{m}$, body width at excretory pore $32.8 \mu\text{m}$, body width at anus $17.4 \mu\text{m}$, stylet length $16.6 \mu\text{m}$, stylet knob height $3.2 \mu\text{m}$, stylet knob width $4.2 \mu\text{m}$, head end to metacarpus valve $71.4 \mu\text{m}$, excretory pore to head end $140.8 \mu\text{m}$, tail length $13.8 \mu\text{m}$, spicule length $32.9 \mu\text{m}$, gubernaculum $9.3 \mu\text{m}$; ratios-a 32.7, stylet knob width/height 1.3, c 105.1, excretory pore 9.7%.

(4) Males: Observations and measurements are from only two males mounted in lactophenol found within one gall (Table 2). Males rare, body vermiform, tapering anteriorly, bluntly rounded posteriorly. Cuticle with distinct annulations. Lateral field with seven to eight lateral lines, not areolated. Head region set off; head cap prominent, narrower than head region (Fig. 3A-B). Cephalic framework moderately sclerotized. Stylet moderately developed; cone straight, slightly longer than shaft, tip pointed; base of cone broadened near junction with shaft. Shaft cylindrical, slightly broadened posteriorly. Knobs set off from shaft, rounded, sloping posteriorly (Fig. 3A-B). DGO $6.2 \mu\text{m}$ in mean. Metacarpus oval, with large valve. Hemizonid anterior to or just at the level of excretory pore (Fig. 3A-B). Testis one, directed anteriorly. Spicules identical. Head rounded, set off. Blade arcuate, tapering towards tip.

(5) Second stage juveniles: Measurements are from 90 second-stage juveniles in 1% formaldehyde were presented in Table 4. Body vermiform, tapering at both ends, but more so posteriorly. Body annulations distinct, becoming larger and irregular in posterior tail region. Lateral field with six lateral lines, not areolated (Fig. 3D). Head region slightly set off, no annulation seen in light microscopy. Head cap high, narrower than head region. Cephalic framework weakly sclerotized; vestibule and vestibule extension distinct (Figs. 3C-D; 4C-D). Stylet slender; stylet cone straight, pointed, increases in width gradually posteriorly; shaft cylindrical, may widen slightly posteriorly. Knob small, slightly separate, rounded (Figs. 3C-D; 4C-D). DGO $5.2 \mu\text{m}$ in mean. Procorpus faintly outlined. Metacarpus oval, with prominent valve (Figs. 3D; 4C).

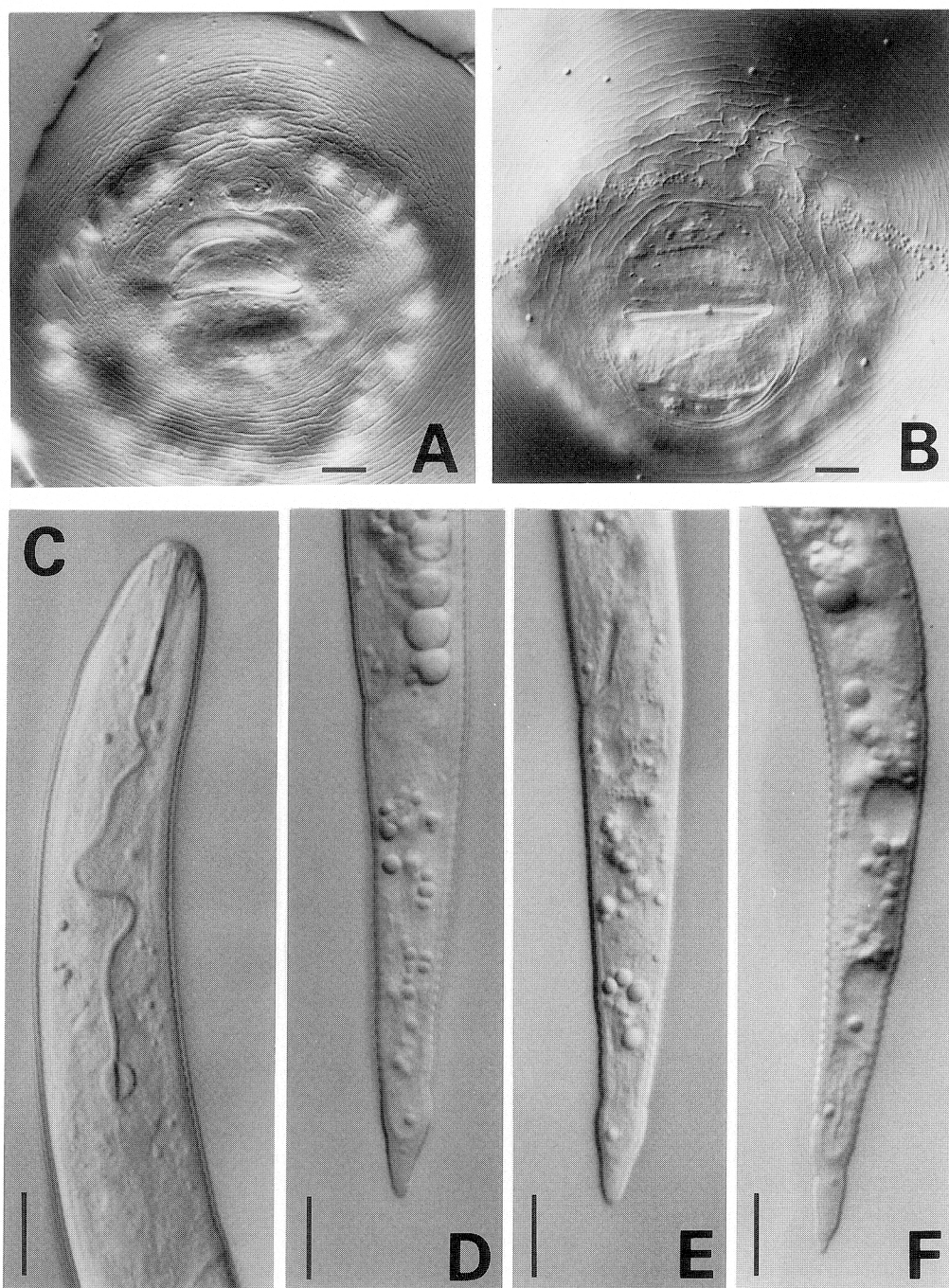


Fig. 4. Light microscopic photographs of *Meloidogyne ichinohei* n. sp. A-B) Perineal patterns of female. C) Esophageal region of second-stage juvenile (lateral). D-F) Tails of second-stage juveniles (lateral). Each bar=5 μ m.

Esophago-intestinal junction indistinct, at level of nerve ring. Gland lobe variable in length, with three nuclei. Hemizonid just in front of excretory pore, sometimes appears posterior depending on the angle of observation (Figs. 3D; 4C). Excretory pore to head end 72.8–100.0 μm (mean of 17 paratypes 88.6 μm , standard error of mean [SE] 1.20, standard deviation [SD] 6.59, coefficient of variance [CV] 7.34%), which is 16.3–20.5% (mean of 17 paratypes 18.4, SE 0.19, SD 1.06, CV 5.73) of the body length. Tail tapering gradually towards the end, usually abruptly narrowing at the level of the hyaline tail terminus; hyaline tail terminus distinct; tip rounded; the shape of the hyaline tail triangle, but tail tip variable even in a cohort of one female, sometimes protrudes to finely rounded tip, and various of intermediate forms observed (Figs. 3E–H; 4D–F). Rectum undilated in the measured 90 individuals and 17 paratypes. Phasmid obscure, 1/2–2/3 tail length posterior to anal opening.

(6) Eggs: 50 eggs in distilled water were measured. Length 18.7–28.5 μm (mean 23.4 μm , SE 0.03, SD 0.22, CV 9.34%); width 10.2–12.2 μm (mean 11.2 μm , SE 0.07, SD 0.48, CV 4.28%); length/width ratio 1.6–2.6 (mean 2.1, SE 0.03, SD 0.23, CV 11.07%). Morphology similar to that of eggs of other *Meloidogyne* species. Egg shell without markings in light microscopy.

2) Type host and locality

Roots of *Iris laevigata* (rabbit-ear iris) cultivars mixed, cultivated in a paddy field in Hisayama, Fukuoka, Kyushu, Japan.

3) Type specimens

Holotype (female): Isolated from roots of the type host, collected from the type locality. Slide no. AT9201, deposited at the "Herbarium and Insect Museum" of the National Institute of Agro-Environmental Sciences, Kannondai, Tsukuba, Ibaraki, Japan. Allotype (male): the same data as holotype. Slide no. AT9202, deposited at the same location. Paratypes (females, one male, second-stage juveniles and perineal patterns): same as holotype. Slide nos. AT9203–AT9211, deposited at the same location. Slide nos. AT9212–AT9214, deposited at the Plant Nematology Laboratory, Kyushu National Agricultural Experiment Station.

4) Diagnosis

The *M. ichinohei* female has a unique combination of characters such as prominent posterior protuberance, laterally located neck, faint, round and broken perineal pattern, and posterior position of excretory pore. Second-stage juveniles have a relatively long (470 μm) body, six lateral lines, large (31.3), high head cap, small stylet knob, long DGO (5.2 μm), almost always undilated rectum and short hyaline tail (7.7 μm).

5) Relationships

The identification of *M. ichinohei* n. sp. is rather easy, because this species has a lot of unique diagnostic characters. *Meloidogyne* species in which females have posterior-protuberances and laterally located necks were once classified in the genus *Hypsoperine*, but this was synonymized with *Meloidogyne*¹¹⁾. *M. ichinohei* n. sp. would be a typical *Hypsoperine* if it genus was still recognized. *M. acrona*^{4, 5)} and *M. megriensis*¹³⁾, the species once included in *Hypsoperine* have somewhat obscure perineal patterns like *M. ichinohei* n. sp. and the characters of *M. kralli*¹⁰⁾ are similar to those of *M. ichinohei* n. sp., *M. ichinohei* n. sp. differs from *M. kralli* in having a set off head, more posteriorly situated excretory pore (48.7 μm vs. 15.8 μm), less and shorter striae in the perineal pattern of the female; larger DGO (5.2 μm vs. 4.4 μm), undilated rectum, shorter hyaline tail (7.7 μm vs. 17.4 μm) and blunter tail tip in the second-stage juveniles. *M. ichinohei* n. sp. can be distinguished from *M. megriensis* in having larger DGO (6.2 μm vs. 3.3 μm), more posteriorly situated excretory pore (48.7 μm vs. 29.3 μm), and less and shorter striae in the

perineal pattern of the female; headcap without visible annule in light microscopy, larger a (31.3 *vs.* 23.2), shorter stylet (11.3 μm *vs.* 13.8 μm), and less constricted tail terminus in the second-stage juveniles. *M. ichinohei* n. sp. most resembles *M. acronea*, from which *M. ichinohei* n. sp. is distinguishable in that it has a set off head with prominent annulation, larger DGO (5.4 μm *vs.* 3-4 μm) in the females; larger number of lateral lines (6 *vs.* 4), larger DGO (5.2 μm *vs.* 2-3 μm), and longer hyaline tail (7.7 μm *vs.* 3.5 (2-4) μm) in the second-stage juveniles.

This species is named after Dr. M. ICHINOHE who reported the occurrence of *Meloidogyne* species on *Iris laevigata* for the first time and has made many contributions to the development of nematology in Japan and the world.

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I would like to thank Mr. K. YOSHIDA, who noticed and led me to the place of occurrence of *M. ichinohei* n. sp.. I also give thanks to Dr. K. NAKASONO of the Kyushu National Agricultural Experiment Station for his valuable advice.

LITERATURE CITED

- 1) AIHARA, T., YUHARA, I. and YAMAZAKI, K. (1981) *Meloidogyne camelliae* found on three species of Theaceae; the first report of the native land of the nematode. Jpn. J. Nematol. **10**, 8-15 (in Japanese with English summary).
- 2) ARAI, K. (1967): On the new nematode parasitizing *Iris* belonging to the genus *Meloidogyne*. 11th Ann. Meet. Jap. Soc. Appl. Ent. Zool. 41. (Abstract; in Japanese)
- 3) ARAKI, M. (1992): The first record on *Meloidogyne marylandi* JEPSON and GOLDEN, 1987 from *Zoysia* spp. in Japan. Jpn. J. Nematol. **22**, 49-52.
- 4) COETZEE, V. (1956) *Meloidogyne acronea*, a new species of root-knot nematode. Nature **177**, 899-900.
- 5) COETZEE, V. & BOTHA, H. J. (1966): A redescription of *Hypsoperine acronea* (COETZEE, 1956) SLEDGE and GOLDEN, 1964 (Nematoda: Heteroderidae), with a note on its biology and host specificity. Nematologica **11**, 480-484.
- 6) ESSER, R. P., PERRY, V. G. & TAYLOR, A. L. (1976): A diagnostic compendium of the genus *Meloidogyne* (Nematoda: Heteroderidae). Proc. helminthol. Soc. Wash. **43**, 138-150.
- 7) HIRANO, K. (1984) On the root-knot nematode detected from Bermuda grass. 28th Ann. Meet. Jap. Soc. Appl. Ent. Zool. 158. (Abstract; in Japanese)
- 8) ICHINOHE, M. (1967): On the two species of nematodes in the family Heteroderidae from Japan. 11th Ann. Meet. Jap. Soc. Appl. Ent. Zool. 41. (Abstract; in Japanese)
- 9) INAGAKI, H. (1985) The plant parasitic nematodes important in Japan and related researches. JARQ **18**, 194-201.
- 10) JEPSON, S. B. (1983): *Meloidogyne kralli* n. sp. (Nematoda: Meloidogynidae) a root-knot nematode parasitising sedge (*Carex acuta* L.). Revue Nématol. **6**, 239-245.
- 11) JEPSON, S. B. (1987): *Identification of root-knot nematodes* (*Meloidogyne species*). C·A·B International, Wallingford, 265 pp.
- 12) NISHIZAWA, T., HOSOTSUJI, T. & YOSHIDA, M. (1984) On *Meloidogyne graminis* newly detected from Japan. 28th Ann. Meet. Jap. Soc. Appl. Ent. Zool. 158. (Abstract; in Japanese)
- 13) POGOSYAN, E. E. (1971): *Hypsoperine megriensis* n. sp. (Nematoda: Heteroderidae) in the Armenian S.S.R. Dokl. Akad. Nauk Arm. SSR **53**, 306-312. (in Russian)
- 14) SASSER, J. N. (1977) Worldwide distribution and importance of the root-knot nematodes, *Meloidogyne* spp. J. Nematol. **9**, 26-29.
- 15) SOUTHERY, J. F. ed. (1970): *Laboratory methods for work with plant and soil nematodes*. Her Majesty's Stationary Office, London, 148 pp.
- 16) TOIDA, Y. and YAEGASHI, T. (1986) Description of *Meloidogyne suginamiensis* n. sp. (Nematoda: Meloidogynidae) from mulberry in Japan. Jpn. J. Nematol. **14**, 49-57.
- 17) TOIDA, Y. & YAEGASHI, T. (1991): Revision of a record on *Meloidogyne thamesi* from mulberry in Japan. Jpn. J. Nematol. **21**, 48.

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和文摘要

カキツバタに寄生するネコブセンチュウの新種、
カキツバタネコブセンチュウ
(*Meloidogyne ichinohei* n. sp.)

荒城 雅昭

福岡県久山町でカキツバタから見出されたネコブセンチュウは、雌成虫では尾端が著しく突出し、首が体の側方に位置する、会陰紋の条線が著しく薄弱等の著しい特徴を示し、第二期幼虫では半月体が排泄孔の直前、直腸は膨大部を持たず、体長約470 μ m、a 値約31、尾長約54 μ m、口針長約11 μ m、背部食道腺開口部から口針節球までの距離約5.2 μ m、尾端は変異が多いが鈍い三角形状であった。本種は同属の既知種とは明らかに異なっており、水田の湛水状態で発生する、根こぶの外には卵のうを産出しない等本属の種には稀な生態的特徴を示した。本ネコブセンチュウは最も類似する *M. acronea* や *M. megriensis* とともに明らかに異なるため未記載種と認め、*Meloidogyne ichinohei* と命名した。本種の雄成虫は極めて稀であった。本種は1967年に新井、一戸が埼玉県で発生を確認し、報告したネコブセンチュウと同じものと考えられる。本種の種小名は、カキツバタのネコブセンチュウを最初に報告し、我が国の線虫学の発展に大きく貢献された一戸稔博士に献名したものである。本種の和名はカキツバタネコブセンチュウとしたい。